Science and the State. By Stanley Coulter.

Presidential Address, Indiana Academy of Science, December 30, 1896.

I recognize the fact that innovation is dangerous, especially when it involves an attempt to give definite form to thoughts, which in varying degrees of distinctness are common property. Yet, despite this danger, I feel constrained to depart somewhat from the usual line of presidential addresses, and, instead of presenting a paper based upon research work or upon achievement in any one department of science, to treat in somewhat broad lines the *relation of science to the State*.

I trust that I may be able to show that the relation is one which involves duty—personal and associate—offers opportunities and opens splendid possibilities. I am led to this course, partially, at least, in the hope that the existing relation between the Academy and the State may be shown to be not only a natural one, but one of extreme mutual advantage.

Science, as every other branch of knowledge, may be considered from two points of view, and the view-point has much to do with the aspect she wears. To the student filled with the scientific spirit the truths she offers are not only inspiration, but sufficient reward. In no other guise can she wear so fair a form.

To the mass of humanity science is beautiful only as she is useful, worthy as she is helpful.

I am one who stands for the exceeding strength and beauty of pure science, who believes it not only strong and beautiful, but fundamental, the *sine qua non* of the useful, and yet as one who is forced to feel that perhaps the world has gained more from "Dobbin" than from "Pegasus." It is possible, too, that you and I may have wrong conceptions of just what is meant by the term pure science.

The old monastic idea of the scholar and of scholarship still persists. It finds, perhaps, its highest utterance in Prof. Woodrow Wilson's address at the Princeton Sesquicentennial celebration, where he says that for him the university is—

"A place removed—calm science seated there, recluse, ascetic, like a nun, not knowing that the world passes, not caring if the truth but come in answer to her prayer; and literature, walking within open doors in quiet chambers with men of olden time, storied walls about her and calm voices infinitely sweet; here 'magic casements opening on the foam of perilous seas in fairy lands forlorn,' to which you may withdraw and use your youth for pleasure."

It finds its every-day utterance in the sneer of the party organ at the scholar who raises his voice in affairs political, and in the expressed belief of the masses that scholars are impractical and theoretical. I care not from what source it may

come or with what authority it may be voiced, such a conception of the scholar and of scholarship is utterly at variance with existing facts. I believe this to be true in all realms of thought. I know it to be true in the realm of science. The development of this wonderfully brilliant and complex composite, which we call modern civilization, has been due to the interplay of many factors, and not the least of these in these latter days has been science. During the last decade, indeed, science seems to have been the dominating factor in human affairs. It is not necessary in this presence to recount the manifold applications of the truths of science to the affairs of every-day life. Science has stretched out her hand and touched transportation and manufactures and agriculture, and with the touch has given a fuller and more abundant life. She has gone into the home and municipality, and by her presence has minimized the dangers of disease. She has entered the office of the physician and surgeon and given a power that even in this day of wonders seems marvelous. Her influence is felt in school, in philosophy, in church and is surely, though perhaps somewhat slowly, bringing these great forces into a closer touch, a more complete harmony with the life that is. Each day in the clear light of the truth, given as the rewards of her devotees, clouds of superstition and ignorance lose form and vanish into nothingness.

To one in touch with science and her achievements she seems no "*recluse*," no "*ascetic*," very little "*like a nun, not knowing that the world passes*," but rather as a virile force pervading the world in all of its affairs, a force as potent as pervading.

And yet in spite of this broad view there exists in our own cases even a somewhat natural tendency to withdraw from the affairs of common weal into the shell of specialty. We justify this withdrawal by some plea of "truth for truth's sake" or talk learnedly about "pure science" as if it were a thing apart from human affairs. The fact plainly stated is, that science has not done as much for the State as it should. I do not refer especially to Indiana and the scientist of Indiana, but to science and the State in the broadest possible application of the terms.

The monastic idea has prevailed too largely among scientists, and science has not done its full duty by the State. Do not imagine for a moment that I am tacitly admitting the converse of the statement that the State is doing for science more than it merits. The failure in duty is mutual. Science has largely failed to seize her opportunities, the State has almost utterly failed to utilize one of her most potent forces. Many things have conspired to bring about this state of affairs, one no doubt, that somewhat vague something known as "practical politics." Another, equally vague ideas on the part of scientists as to what science can do for the State.

I may premise by saying that the State as a rule can not deal in intellectual futures. It can not or should not make appropriations for investigations to run through long series of years, the ultimate outcome of which is merely the solution of some scientific problem. To the scientist such problems are of the profoundest interest, their solution seems to him of almost paramount importance, and yet a moment's reflection will serve to show that the State can not properly provide for such work. The State has to deal, not with the general problems of science, save as they are applicable to immediate needs, but with the welfare of her citizens. Welfare being a term under present conditions, which seems to be largely material in its interpretation, incidentally intellectual, remotely moral.

If I am right in this view, it follows that the first duty of science to the State is the *development and protection of her material resources.* This may appear, at first, a lowering of the high ideals many of us hold, and yet as we increase the resources of our commonwealth, we manifestly increase the possibility of the attainment of our high ideals. "Untoward circumstances" has blighted many a scientific aspiration. An increase in material prosperity is the shortest cut to an increase in the intellectual activity and development of the State. As intellectual activity is increased, the constituency appreciating the value of scientific work increases, opportunities broaden and achievement is possible. I am inclined to think that the duty to increase and conserve the material resources of the State may be found to be the all inclusive duty of science, since if thoroughly done, all other desired conditions will naturally follow. To become concrete. For a long series of years the State has maintained a geological survey. I believe that in spite of the numerous criticisms that can justly be made upon the published reports, no wiser or more productive expenditure of public moneys has been made. If all conditions are considered, limitations of opportunity, uncertain and meagre appropriations, illogical selection of the official chief by popular vote, control over the extent and character of the reports by committees and the sundry other stumbling blocks in the way of the highest efficiency, the results are surprisingly good. As individuals and as an association, I believe we have failed in our duty to the State as regards these publications. It goes without saying that the work of the State Geologist would have been made infinitely simpler, that his reports would have had a higher value if he had received during the past ten years the hearty individual and associate co-operation of this Academy. We have, in a degree, lost an opportunity to make science and the scientist a factor in the material advance of the State.

In my opinion the first duty of the members of this Academy is a complete study of the material resources of the county in which they reside. Not, for example, a list of flowers, unless it is indicative of soils, of drainage, of forest wealth, of forage resources, of the numerous facts of which the list stands as index. Not a mere list of birds, or fish, or insects, interesting though such lists be, but the conditions of which they stand as the visible sign. Not catalogues of fossils, nor sections of wells, save as they speak of mineral resources, of what may be called the unutilized wealth of the State. This material should be furnished to the State Geologist for proper correlation and use. The Academy has enough work of other character, of equal value to turn all of this material over to the State Geologist.

These facts in the hands of individuals are practically valueless, usually travelling into a swift and secure oblivion through the columns of a county paper or the introduction to a county atlas. In the hands of the State Geologist these same facts would often prove of supreme importance, saving weary hours of study and laborious trips of investigation. Within the year such a wealth of facts concerning the resources of the State could be collected without especial effort on the part of any one person, that many conclusions could be drawn with almost absolute precision. Conclusions that would serve to develop new industries on the one hand, or prevent the useless expenditure of thousands of dollars on the other. I say it is a duty you and I owe the State—we have always owed it, but the duty is now an imperative one since the State has given official recognition to this organization.

Another duty is in the conservation of the wealth of the State. A collation of facts that will tend to the conservation of forests, to the destruction of weeds, the protection of birds and fish, the warding off of plant and animal diseases, improved sanitation in homes and municipalities, the increase of crop production. All of these are within the domain of science, and it is only through the labors of scientists that success will be achieved. No one has a higher and more profound respect for pure science than I. No one feels more deeply the truth that pure science—the theoretical, if you please—must precede the practical; is, indeed, the foundation of the practical. But if science expects to justify herself to the State, and hopes for continued recognition by the State, she must from time to time, at least, descend from the heights of pure science and mingle in the affairs of daily life. She must not always claim; she must occasionally do.

This duty of developing and conserving the material resources of the State I believe to be an imperative one, and one which, unfulfilled, leaves us culpably derelict.

But the duty of science to the State does not cease with the discovery of truth. It extends to its dissemination in a fairly intelligible language, with sufficient suggestions as to its relations to make it practically useful. In this matter, too, I claim that science has neglected manifest duty to her own injury. Either we have been held back by modesty, not usually considered an attribute of scientists, and refrained from publication, or we have sought publication in some journal of high rank in our own line of work, but of extremely limited circulation. When forced by occasion to use other media for relieving intellectual congestion, the articles so bristle with technicalities and multiplied allusions to German and French and Russian and Italian authorities that the hopeful neophyte turns pale and the man of affairs, eager to see what science has in store for him, turns away in disgust. As a rule, when called upon for a popular presentation, a primer style is adopted, from which an intelligent public turns with equal disgust. That the statements of science in certain presentations must have technical precision no one questions, and these presentations have their place in technical journals; but surely, after the technical language has been stripped off, and the curves of this and that and the other have been eliminated; when the foot-notes have all been dropped and the ready familiarity of the author with all languages lost sight of, there should be some small residuum of truth capable of interpretation into every-day language. It is this residuum of truth, clearly put, with relations definitely stated, that science should disseminate. It is this that will give standing and credit among the people, and until such credit is gained scientists will find themselves hampered at every turn by the wearisome iteration, impractical—theoretical. It is this dissemination of a true science in a popular, not puerile form, that is needed above all things. It is needed that our citizens may have a knowledge of all that class of facts which intimately concern their daily life, that they may know the limitations nature has placed about their efforts—may know the possibilities she opens before them; that they may have awakened in them the knowledge that through their efforts and observations new truths may be discovered which will become the heritage of their children. I am convinced that scientists have much to answer for because of this failure in duty. I am equally convinced that they have been repaid doubly for all of their sins of omission, in the almost universal lack of appreciation of the character and importance of their work. This accurate popularization of scientific truth is absolutely necessary if our work as scientists and as an Academy is taken at its full value. Did you ever think of it? Appropriations for proceedings of societies of horticulture, of agriculture, of swine-breeders, of chicken raisers, of bee-keepers, of tile-makers, without question, but grave doubts as to the publication of the

proceedings of the Academy of Science because of lack of practicality! If there is one practical thing in these days of ours it is science; if there is one form of truth which more than all others underlies and pervades all our industries, it is scientific truth; if there is one form of knowledge which more than any other seems to condition public prosperity—even to condition duration of life—it is scientific knowledge. It is a startling commentary on the neglect of duty of men of science that in these last years of this century of scientific achievements, achievements which year by year become more marvelous, more wide-reaching in their effects; when achievement seems only limited by man's daring, to hear solemn discussion as to the practical value of scientific publication. The truths of science that are fundamental, the practical application of these truths, should be the common property of every man and woman, of every school child, in the State. The scientist should be nature's interpreter to the people. Too often he has merely striven to interpret himself to others of his kind. I repeat that this Academy as a body, and through its members, owes the duty to the State of disseminating scientific truth in a straightforward, clear-cut way, that the people may have put into their hands all of the truths of science which have immediate practical bearing. If a man who accumulates money hoards it he is a mean man, a miser. The man who accumulates useful knowledge and hoards it is infinitely meaner than the miser.

Among the best intentioned educational movements in secondary schools during the last few years has been that which has introduced nature study into the grades. Following the letter of the recommendation of the committee of ten, the spirit of the recommendation has often been utterly overlooked. Nature study has been so associated with language and number and form studies that nature has flown out of the window, while number and language and form remained. Where the intention is most honest, the work is imperfectly co-ordinated, without sequence, practically without purpose. The real aim of scientific study seems often utterly misconceived, for science work consists not in the mere collection and pigeon-holing of facts, but in the development and strengthening of certain specific intellectual powers. It is evident that this state of affairs exists because scientists have not sufficiently concerned themselves in the movement to bring it success. A movement which promises so much for the symmetrical intellectual development of the youth of the State, which promises so much for science itself, is surely of sufficient importance to merit some attention from every true scientist and systematized and wisely directed efforts for its success by this Academy as a body. My position is, that this Academy should stand for the combined wisdom of its members in all matters scientific which pertain to the

common weal, and that its views in all such matters should be so voiced as to carry the influence such combined wisdom and experience merits. I believe, then, that as individuals, and as an associate body, we owe a definite duty to the State in the wise fostering of all efforts to increase the amount and improve the quality of the science work in our secondary schools. It may be urged that all of this is beyond the province of this body. As I conceive the province of science, however, such duties as I have indicated seem the most natural and forceful way of showing, even to the veriest gradgrind, the very close and eminently practical relationship existing between science and the State.

All I have said implies that the scientist recognizes himself as a loyal citizen of the State in which he works, and that he is as jealous of her honor, as careful for her prosperity, as watchful over her interests as the man who edits a newspaper, who practices law or runs for office. But where the monastic idea prevails, where the laboratory so absorbs that he loses sight of his citizenship, he is derelict in duty and discredits science.

On the other hand, the State, through her legislators, may be said to owe certain duties to science. One of the most patent of these is official recognition of the value of scientific work to the State. From the days of the New Harmony Settlement, when Indiana was the Mecca of all the Scientists of the land, when the Owens and Say and Lesquereux and others were not only revealing the natural wealth of the virgin State, but were adding lustre to her intellectual record, down to the present time has science and the scientist done much for the State. The exploitation of our coals, of our stone quarries, of our clays, of our forest resources, with the development of the industries dependent upon them, has been based directly upon the work of the scientist. As the result of the study of farm products, of plant and animal diseases and their remedies, of soils and fertilizers, thousands of dollars annually have either been saved to the State or added directly to its wealth. In manifold ways, without withholding, has science given largely and liberally to the State. It would seem but a natural thing in view of such a record for the State to assume that science still had something in store for her; to assume that when she spoke her utterances would have value. It would seem but a just thing when the scientists of the State are associated together and have organized definitely for an increase of knowledge of the resources of the State to at least provide for the publication of this knowledge. It would seem to be the high-water mark of practicality as well as economy to secure something for nothing. The worker has the satisfaction of work well done, the State all the results of his labor.

Points of view vary, however, and what may seem just and generous to the scientist, may not have such a fair seeming to the legislator. But I believe that an honest and intelligent study of the contributions of science to the material wealth and intellectual development of the State will furnish a sufficient warrant for the views advanced.

The obvious way in which this official recognition could be given objective form is in a permanent appropriation for the publication of the proceedings of this Academy—an appropriation sufficiently liberal to insure the proper presentation of its work. The expense would be most trivial compared with the results such action would secure. Results which would extend beyond the material and would powerfully upbuild and support the educational system of the State. It seems to me that a failure to utilize such an agency is inexcusable. I believe that if there were no material interests involved, the proper encouragement of scientific investigation, regarded from a purely intellectual standpoint and because of its reflex influence upon the character of the instruction in the secondary schools, is within the province of the State and may fairly be classed as one of its duties. The history of such action and its results in other States serves to emphasize this view. I am not, however, so much interested in the duty of the State to science as in the converse, and feel in nowise moved to instruct legislators in their duties.

If, however, there is a full recognition of the mutual obligations existing between science and the State, then the organization of this Academy opens wide the gate of opportunity.

Before suggesting these opportunities, allow me to say that I believe that, perfect as is our organization, it can be made far more productive of results by a proper co-ordination and distribution of work. There are certain investigations which can not be made by individual workers which can easily be carried on in the laboratories of the colleges. There are other investigations which can only be carried to a successful conclusion by the co-operation of many persons or in some cases of several colleges. It is one of the most difficult things in the world to recognize the limitations our environment imposes upon us, but a failure to recognize such limitations leads often to a sad waste of energy. To properly utilize the energy of the Academy there should be a co-ordination of the scientific work of the State of such a character as would at least prevent overlapping and valueless repetition, as would give the individual worker his proper field, thus freeing the larger laboratories for the broader problems demanding for their solution large equipments and libraries. Apparently, the only thing that stands in the way of such co-operation and such a practical distribution of work is the desire most of us have to pose as past masters of science. Is it too much to say a

feeling of jealously, a fear lest some other worker will gain more of reputation or popular favor? I much fear me that were we fully truthful with ourselves some slight leaven of professional jealousy might be found working in our actions. It seems clear to me—very clear indeed—that before we can properly seize the opportunities offered, there must be some practical, though not necessarily formal co-ordination of work.

Take the opportunities for concerted, co-ordinated work in a single science and notice how great their practical as well as theoretical value. There are certain natural resources of the State which may be materially developed in some instances, or have their utility greatly increased in others, by full and complete chemical studies. Perhaps that of the greatest importance from a commercial standpoint is the thorough and complete investigation of the clay deposits of the State. I will be pardoned for saying that I think that the last volume of the Geological Reports fully justifies all the grants ever made to the survey by the preliminary investigation of the clay deposits of the coal bearing counties. The certain outcome of the work is the rapid development of new industries, based upon this formerly unutilized resource, which will annually produce thousands of dollars in excess of all appropriations ever made for the survey. But this investigation has but begun, and a full knowledge of the clay deposits will only be possible after many years, unless there be in the various laboratories of the State full and complete studies made of the possibilities of these clays in various directions. Some are fitted specially for tile, some for paving brick, some for building brick, some for pottery, special uses which can only be determined by studies in the chemical laboratory or by the costly experiments of actual manufacture. From work of this character would naturally follow monographic work upon the chemical problems involved in the successive steps in the manufacture of each of these various products. Such work would give almost immediate return and would appeal to a much larger constituency than the scientist can usually hope to reach.

In the line of increasing the utility of resources already developed, it is evident that chemical investigations would reveal many ways in which our coal and gas and oil might be made to yield even richer returns than at present.

That an intimate relationship exists between public prosperity and public health is no longer questioned. It is a matter of popular knowledge, which is taking form in the various voluntary and legalized organizations for the improvement of sanitary conditions in homes and municipalities. This movement suggests another opportunity for concerted chemical work bearing upon these grave problems. No more valuable work for the State could be carried out than that of

a chlorine survey of the natural waters of the streams and springs of the State. A knowledge of the local normal chlorine in the natural waters of the State is almost a necessity, if outbreaks of disease are to be anticipated. Any sudden increase in the amount of chlorine in a given locality, would give warning of possible danger and serve to give direction to the efforts of health officers in averting disease from their districts. A chlorine map of the State is a necessity for its proper sanitary control and this work can only be done satisfactorily and rapidly by the concerted work of an organization, such as this Academy. After the establishment of this chlorine base line there would still be necessary the regular examination of water supplies for purposes of comparison, which could be done in almost every case by the local health officer. Without this base line chemical analyses of water lose much of their meaning.

Correlated naturally with this would be the general examination of water in epidemic districts, the immediate benefits of which are self-evident.

The mineral waters of the State open another field of chemical research work, attractive and of evident value. It is manifest that in the working out of problems, such as these, covering the whole area of the State, there should be the most careful co-ordination, the most perfect division of labor. It does not seem to me that such work is beyond the province of the Academy, indeed it seems to be its supreme province so far as its relation to the State is concerned.

Since I am speaking of chemical research, allow me to suggest that much yet remains to be known of the chemistry of the soils and rocks of the State, much that must be known if in the near future we reach the apotheosis of usefulness, which some one says consists of making two blades of grass grow where one had grown before.

The plant world also offers to chemistry opportunities for investigation in lines not merely of theoretical interest, but of high practical value. The examination of vegetable products—for example, of plants producing sugar, tannin, medicinal properties, etc. How much of unutilized wealth is at our feet, bound up in plants, only waiting the word of science for its release. It is said that one of our smart weeds (*Polygonum amphibirem*), a common plant in marsh regions, contains 18 per cent., by weight, of tannin[1], an amount sufficient, if the statement is true, to justify at least an attempt to utilize it for commercial purposes. This is but an illustration of scores of cases which might be cited to show the possibilities of this form of work.

It is strange when we consider the length of time scientists have been at work in the state, that there is so little of actual knowledge concerning its topographical

[1] Bot. Gaz., vol. i, p. 20.

features, and, stranger still, of its drainage systems. In a general way we recognize the lowlands of the State are located in the southwestern counties, while the highland regions, if they can be dignified, are in the eastern-central counties; we know there are chains of hills in the south and prairies in the north, but beyond these facts we know very little.

We are familiar with the two great drainage systems of the State, but of the minor details essential in the working out of local problems we have absolutety no data—at least none that are at all available. In an attempt last year, in the sanitary laboratories at Purdue, to make a contour map of the State, the paucity of data was strikingly apparent. Had it not been for the railroad levels, not even an approximation could have been reached. It is not necessary to say more than that a moment's reflection will suggest the far-reaching application and value of this work. It is also manifest that the accomplishment of such work is only possible through the intelligent co-operation of the members of a body such as this.

I have purposely omitted thus far any mention of the opportunities that open to biologists. From my point of view they are so numerous and of such importance that they are almost self-evident. Fields that have already been entered show themselves broadening as the work advances. And the work already done suggests yet further worlds for conquest. The biologist still has much to do in the line of plant and animal diseases, infinitely more in the line of sanitation. The accomplishment of yesterday in these lines serves merely as the incentive for the work of to-day. There is little danger that work of this character will be neglected. There are, however, other problems, the solution of which depends upon a patient gathering of facts almost innumerable, and an equally patient study of these facts in their true relations—problems which by their mere statement carry little idea of their real importance. Systematic botany has, I presume, in the opinion of most people, about as little to do in the realm of practical affairs as any branch of knowledge. Such an opinion is doubtless true if systematic botany consists, as is the popular conception, in the mere cataloguing and naming of plants. The systematic botany of to-day is, however, far more than this; it involves studies of plants in their relations to soil and rainfall, to heat and light, to air and mechanique, to each other, to animal life. More and more clearly out of the great masses of facts being collected in ecological studies is the truth becoming apparent that plants stand as the sure sign of the natural agricultural capacity of the soil upon which they grow.

Allow me to quote from Mr. Corille's "*Botany of the Death Valley Expedition*," a report, which is a model in every way. After showing that trees and shrubs

are most reliable as zonal guides, he says: "Shrubs and trees, being commonly larger than herbaceous plants, reach higher into the air and penetrate more deeply into the soil, thereby subjecting themselves to a wider range of conditions than do these smaller plants. They also, by continuing throughout the year exposed to successive, varying seasonal conditions, complete the full round of their possibilities in environment. They therefore stand as the most complete summation that can be attained of the natural light, heat, moisture, food, air and mechanique of any area; in other words, a sure index of the natural agricultural capacity of the soil upon which they grow. From a utilitarian point of view, too much stress can scarcely be laid upon this fact. It has been the practice of agriculturists to gauge the capacity of soils, in regions new to the plow, by observations on rainfall, temperature, cloudiness, chemical composition of the soil, drainage, and many other phenomena, or by the even more laborious process of experimenting on every farm with each kind of cultivated product; ignoring the fact that this determination can be greatly hastened, cheapened, and authenticated by correlating the natural vegetation, especially that made up of the trees and shrubs, with that of other regions, whose agricultural capacities are known."[1]

A careful gathering of facts of the character indicated regarding our native flora would not only give results of the highest practical value, but would also serve in a great measure to relieve chemists and agriculturists of irksome work, the results of which at best could be of but local value. In this broader view even systematic botany has opened before it a splendid opportunity, for I know to my sorrow how few facts of this kind are available. Here, also, it is evident that data sufficiently extended can only be secured through intelligent co-operation of botanists throughout the State. No more attractive field offers; none in which the prospect of valuable returns is more promising.

A recent article in *Nature*, by M. T. Masters, abstracted in the *Popular Science Monthly* for October, 1896, on "Plant Breeding," is also suggestive of work of great practical value along botanical lines. Quoting briefly: "The natural capacity for variation of the plant furnishes the basis on which the breeder has to work, and this capacity varies greatly in degree in different plants, so that some are more amenable and pliant than others. The trial grounds of our great seedsmen furnish object lessons of this kind on a vast scale. The two processes (selection and cross-breeding) are antagonistic. On the one hand, every care is taken to preserve the breed and to neutralize variation as far as possible, so that the seed may "*come true;*" on the other hand, when the variation does occur the observation of the grower marks the change, and he either rejects the plant,

[1] Botany of the Death Valley Expedition. 18

manifesting it as a "*rogue*" if the change is undesirable, or takes care of it for further trial if the variation holds out promise of novelty or improvement. Where the flowers lend themselves readily to cross-fertilization by means of insects, it is essential, in order to maintain the purity of the offspring, to grow the several varieties at a very wide distance apart. Some apparently slight variations, which, even to the trained botanist, are hardly noticeable, may be of great value commercially – as, for instance, of two apparently almost identical varieties of wheat, one may be much better able to resist mildew and diseases generally than another; some again prove to be better adapted to certain soils, or for some climates, than others; some are less liable to injury from predatory birds, and so on. So far we have been alluding to variations in the plant as grown from the seed, but similar changes are observable in the ordinary buds, and gardeners are not slow to take advantage of these variations. The field is one of great scientific as well as commercial interest, and a thoroughly equipped biologist would probably soon distance the ordinary gardener who works by rule of hand in producing and perpetuating valuable variations."[1]

This audience will carry the thought of opportunity into other lines of scientific work without additional detail. The zoölogists are hard at work, under careful organization, and will at this meeting show something of the scope of their work, with the results already reached. The engineers, with all their energies, have as yet been unable to fully occupy their territories, so manifold are their fields for investigation.

All that I have suggested involves no neglect of pure science. Neither does it necessarily involve the abandoning of work which, with our present knowledge, seems purely theoretical. It does not suggest the introduction of the mercenary or utilitarian idea into scientific work. It is only an intimation of how, by a judicious and well-ordered treatment of what may be called the by-products of our activity much good may be accomplished for science, much for the State. As the manufacturer often finds that the careful utilization of the by-products conditions success, so the scientist may find that his success depends upon his contributions to the general good. Every truth will, of course, at some time take its appointed place and be assigned its true value; but many truths of science as yet stand isolated—unrelated, marvelous products, often, of skill and patience, but, until they find their true place, of little general interest. Through facts such as these scientist may appeal to scientist, but it is through simpler facts of readier application that science appeals to the State.

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[1] Pop. Sci. Monthly, Oct., 1896, pp. 859-860.

I have thus in the broadest lines indicated what seemed to me some of the evident duties of the Academy to the State, and what seemed to be opportunities for increasing its value to the State. All are dependent upon the combined work of many individuals. Few, if any, can be accomplished save through an organization such as this.

I look over the secondary schools of the State and find that the teachers of science, with few exceptions, are poorly paid; that science courses are, almost without exception, arranged with reference to recitation schedules rather than to logical sequence of subjects or intellectual capacity of pupils. That science is assigned a value in the curriculum far less than language, or number, or form. I find in our colleges, again, with few exceptions, that while it is not expected that one man can teach both Latin and Greek, it is expected often that one man can teach Botany, and Zoölogy, and Physiology, and Chemistry, and Physics, with other incidental subjects to fill his schedule. I find a prevailing belief that the scientific specialist is a narrow man, when, by the very nature of things, he must be, if a true specialist, one of the broadest of men; a belief, in general, that science is impractical, theoretical, visionary. All this in spite of the fact that far more than any other force has science directed—yes, dominated—the progress of the past decades. I believe the cause of all this to be that science has not been fairly dealt with by her devotees. That the scientist, absorbed in the work of the laboratory, has too often forgotten his citizenship and neglected to transfer to the State the truth which science had placed in his hands. Primarily the objects of the Academy are inspirational, but secondarily, at least, and certainly in its relations to the State, its objects should be eminently practical.

If we fully grasp the idea of this relationship, which I have but imperfectly outlined, the possibilities of science in Indiana are almost limitless. Its influence will be increased, its constituency broadened, its achievements more splendid, and the prophecy of a high place in science, born in the New Harmony days, will have its realization in the effective and beneficent work of this Academy.

The Evolution of the Map of Mammoth Cave, Kentucky. By R. Ellsworth Call.

There probably does not exist elsewhere on earth so famous a natural feature concerning which so little is definitely known as the Mammoth Cave of Kentucky. Its scientific exploration has been so hampered and guarded by a jealous fear of rival interests that no one has been permitted to survey the great cavern and to